The Living World - Part 2

Objectives

After going through this lesson, the learners will be able to understand the following:

- Hierarchy of classification?
- Taxonomic aids

Content Outline

- Introduction
- Hierarchy of Classification
- Taxonomic Tools
- Summary

Introduction

In the previous module we learned about characteristics of life, biological diversity, biological classification, taxonomy and binomial nomenclature. In this module we study the hierarchy of classification and taxonomic aids. One of the most important things about living organisms is that they are found in almost unbelievable numbers. From microscopic organisms to the most gigantic organisms like the elephants and the blue whale, from organisms having the shortest life span like May fly to organisms with the longest life span. The fact is that biologists have recorded 953434 species of animals, 215644 species of plants, 43271 species of moulds and fungi, 8118 species of single celled protozoa and 13033 species of chromists (including, eg. brown algae, diatoms, water moulds) have been described and cataloged *(ref - UNEP Aug 2011)*. However, there are many more millions yet to be described. Thus, the classification of organisms is a big task in order to make the study of living organisms more organized. People classify living things into special groups so as to identify organisms and understand the relationships that exist in a variety of life forms.

Hierarchy of Classification

Classification is not a single step process but involves hierarchy of steps in which each step represents a rank or category. A taxon is a taxonomic group of any rank. It is a taxonomic group of real organisms assigned to a category, whereas taxonomic category represents rank

or level in a hierarchy and does not represent the living organisms. For example, **Reptilia** is a taxon but class is a category similarly **Mangiferae** is a taxon but family is a category.
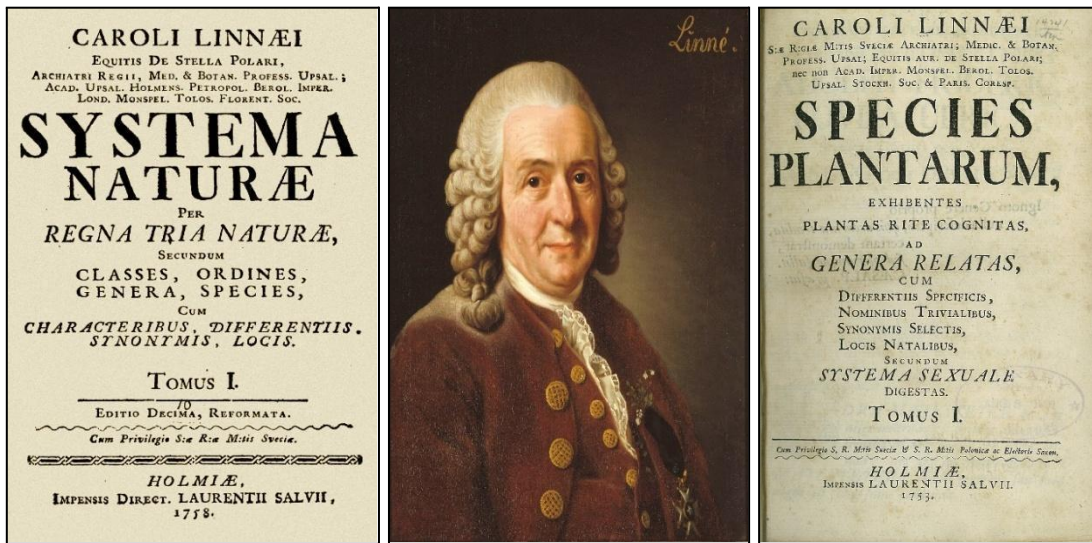
The Linnaean Taxonomic Hierarchy

The Linnaean taxonomy is a formal system for classifying and naming living things based on a simple hierarchical structure, from most general to most similar. He published his system of classification in a book called **Systema Naturae** in 1758 which is still considered to be a foundation book even in modern taxonomy. The basic hierarchy as formulated by Linnaeus is as follows:

<div align="center">

Kingdom

Phylum

Class

Order

Family

Genus

Species

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This very versatile arrangement can be used to classify every living organism, living or extinct.

Categories and their Suffixes

Category	Suffix
Division	phyta
Sub - Division	phytina
Class	phyceae or opsida or ae
Order	ales
Family	aceae
Family (Animal Kingdom)	idae

- **Kingdom**

The highest ranking of organisms in the standard Linnaean system. The term is based on earlier medieval and alchemical ideas - e.g. "animal kingdom" "vegetable kingdom," "mineral kingdom". The original Plant - Animal Kingdom divide was replaced by the Five Kingdom model of Whittaker and Margulies. All animals belonging to various phyla are assigned to the highest category called Kingdom Animalia in the classification system of animals. The Kingdom Plantae, on the other hand, is distinct, and comprises all plants from various divisions. Henceforth, we will refer to these two groups as animal and plant kingdoms. As we go higher from species to kingdom the number of common characteristics goes on decreasing.

- **Phylum**

Referred to as "Division" in the case of Plants and Bacteria. In the standard Linnaean system (and taxonomic systems based on it), a Phylum is the taxonomic category between Kingdom and Class. A phylum is a major ranking of organisms, defined according to the most basic body-parts shared by that group. For e.g., Chordata (animals with a notochord - vertebrates and others), Arthropoda (animals with a jointed exoskeleton) Mollusca (animals with a shell-secreting mantle), Angiosperma (flowering plants), and so on. A number of traditional Phyla - e.g. Protozoa, possibly Arthropoda - are probably invalid (polyphyletic).

- **Class**

In the Linnaean system (and taxonomic systems based on it), a Class is the taxonomic category between Phylum and Order. A class is a major group of organisms, e.g. Mammalia, Reptilia, Gastropoda, Insecta, etc that contains a large number of different sublineages, but

have shared characteristics in common (e.g. warm-blooded, fur, mammary glands in female in the case of mammals, six legs and three body parts in the case of Insects, etc.). As with all groupings, whether a group of organisms ranks as a class or not is a subjective decision, although usually based on the traditional status of that group in earlier literature. The cladistic revolution has caused a reappraisal of these rankings, and rejection or modification of many of these rankings.

- **Order**

In the Linnaean system (and taxonomic systems based on it), the Order is a taxonomic category between Class and Family. An order is group of organisms, e.g. Lepidoptera, Squamata, Primates, etc that although differing quite a bit among themselves still have a large degree of characteristics in common (e.g. all Lepidoptera (butterflies and moths) have minute scales on their wings, a soft-bodied herbivorous larval form (caterpillar), mouthparts in the adult specialized for feeding on nectar, etc.).

- **Family**

Family (Latin: familia, plural familiae) is one of the major taxonomic ranks; it is classified between order and genus. A family may be divided into subfamilies, which are intermediate ranks above the rank of genus. Family, as it relates to taxonomic rank, is between order and genus. Family, then, designates a category of classification that is fairly precise. For example, Family would include categories such as apes and lemurs. They are similar. So within the primate order, the family of apes occurs. Families are characterised on the basis of both vegetative and reproductive features of plant species. Among plants for example, three different genera *Solanum, Petunia* and *Datura* are placed in the family Solanaceae. Among animals for example, genus Panthera, comprising lion, tiger, leopard is put along with genus Felis (cats) in the family Felidae. Similarly, if you observe the features of a cat and a dog, you will find some similarities and some differences as well. They are separated into two different families – Felidae and Canidae, respectively.

- **Genus**

In the Linnaean system (and taxonomic systems based on it), the Genus is the first grouping of species, the ranking between Family or Tribe and Species. Only very closely related species are grouped together in a single genus. The genus is sort of like the surname, whereas the species is the first name. So ***Canislupus***, the wolf, is distinguished from ***Canis familiaris***, the domesticated dog. Although very similar they are still distinct species, but belong to the

same genus. Or in man, Homo erectus and Homo sapiens. Genus comprises a group of related species which has more characters in common in comparison to species of other genera. We can say that genera are aggregates of closely related species. For example, potato and brinjal are two different species but both belong to the genus *Solanum*. Lion (*Panthera leo*), leopard (*P. pardus*) and tiger (*P. tigris*) with several common features, are all species of the genus *Panthera*. This genus differs from another genus *Felis* which includes cats.

- **Species**

In the Linnaean system and biology in general, a species is the smallest basic taxonomic unit used to define living organisms. Species is the fundamental or smallest unit of classification. The term 'species' was recognized from Genus by John Ray. Ernst Mayr defined species as 'A group of potentially interbreeding natural populations of closely resembling organisms'. Taxonomic studies consider a group of individual organisms with fundamental similarities as a species. One should be able to distinguish one species from the other closely related species based on the distinct morphological differences. Let us consider *Mangifera indica, Solanum tuberosum* (potato) and *Panthera leo* (lion). All the three names, *indica, tuberosum* and leo, represent the specific epithets, while the first words *Mangifera, Solanum* and *Panthera* are genera and represent another higher level of taxon or category. Each genus may have one or more than one specific epithets representing different organisms, but having morphological similarities. For example, *Panthera* has another specific epithet called *tigris* and *Solanum* includes species like *nigrum* and *melongena*. Human beings belong to the species sapiens which is grouped in the genus Homo. The scientific name thus, for human beings, is written as *Homo sapiens*.

Taxonomic Aids - Tools for Study of Taxonomy

To identify various species both laboratory and field studies are important. This information gathered about the species needs to be stored for future studies. The actual specimen is collected, preserved and stored for verification for any future reference. This helps in identification of species and their placement in taxonomic hierarchy. There are several aids like Herbarium, Botanical gardens, Museum and Zoological park.

Herbarium

A herbarium is defined as a collection of plants that usually have been dried, pressed and preserved on a sheet. Plant samples are taken from the field and then dried or otherwise

preserved. They are then carefully stored in archival conditions to ensure their longevity. The sheets are arranged in accordance with any excepted system of classification (Usually Benthem and Hooker's system). The storage of sheets forms a repository that can be used for future reference. It provides a quick refer back system and is quite useful for people involved in taxonomic studies. All institutes leading with botanical studies maintain their Herbaria. Students are trained to collect and identify herbarium specimens of local and distant places. The collections housed in herbaria are majorly used for scientific research. Research that might commonly take place in a herbarium includes:

- Ecological research - Mapping current and past ecological and geographic distribution of plants
- Evolutionary history of plants
- Study of plant community dynamics plant communities and their habitats
- Study of Invasive species and weeds
- Molecular phylogenetics
- Classification and naming of plants

Herbarium Technique

- The collection of specimens requires regular field visits; one has to get information about the place, habitat, season and the time of collection of the specimens.
- The field visit helps in gathering information about environmental conditions from specimens that have been collected.
- For collection of specimens one has to carry simple tools such as a digger for digging roots, a scissor for cutting twigs, Knife for woody twigs and a pole with Hook for collecting part of tall trees.

- Vasculum and polythene bags are used to temporarily store fresh shoots to avoid loss of moisture and distortions by drawing and shriveling up. Vasculum is a box of 40 X 60 cm, 20 cm width and 25 cm depth.
- Succulent parts, fruits, tubers, rhizomes are preserved in bottles having FAA (Formalin + Acetic Acid + Alcohol), some of them can also be dried and kept in packets.
- The dried specimens are pasted on the herbarium sheets of standard size 29 X 41 cm. Specimens before fixing are kept upside down on a paper sheet, glue or adhesive is applied and then they are mounted on the herbarium sheet.
- All the pasted specimens are sprayed with fungi sides like 0.1 % solution of mercuric chloride, pesticide like DDT, Naphthalene and carbon disulphide to check the growth of fungi.
- The heavy parts of plants like seeds and fruits are put in a packet and attached with a sheet.

Label 7 X 12 cm is pasted over the right hand corner and carries the following information:

1) Collection number
2) Place / locality
3) Name of collector
4) Date and time
5) Common English name
6) Vernacular Name
7) Scientific name
8) Family
9) Institution

Major Herbaria

Largest herbaria of the world are at Royal Botanical Garden, Kew, England with 6.5 million specimens and museum of natural history.

Paris with 6 million specimens, In India the largest herbarium is at Indian Botanical Garden shibpur, Kolkata called central national herbarium with about 2 million specimens.

Botanical Gardens

Botanical gardens are collections of living plants maintained for reference. It is considered a natural and economical reference system. There are over 525 large-sized Botanical Gardens

developed in various parts of the world. The first modern botanical garden was established in 1544 in Pisa Italy (Padua Botanical Garden by Luca Ghini, a professor of Botany); this garden does not exist today. A botanical garden exclusively growing trees and shrubs is called an arboretum.

The most famous botanical garden is 'The Royal Botanical Garden' in Kew, England. It is extended in 200 acres of land and was founded in 1759 by William Aiton.

The largest botanical garden is the Howrah shibpur, Kolkata it was established in 1787 besides its other main botanical gardens are National Botanical Garden Lucknow, LLoyed botanical garden Darjeeling, garden of Indian Agriculture Institute, Dehradun etc.

A botanical garden usually houses a library, laboratory, Herbarium and museum; it frequently offers teaching and training facilities also.

In a botanical garden, one defines each plant in the garden with the scientific name and family mentioned on the label.

The International association of botanical gardens was established in 1962. It published the international directory of botanic gardens 1983.

Role of Botanical Gardens

1) Provides plant material for comparative taxonomic studies.
2) Functions as an acclimatization center for exotic plants of economic importance.
3) Growing and maintaining records of local flora.
4) Provides material for botanical research.
5) Ex situ conservation of endangered plant species.
6) Improve the environment by providing greenery in big cities.
7) Purify air.

Royal Botanical Garden, Kew   Shibpur Botanical Garden, Kolkata

Museums

Museums are collections of plants and animals for study and reference. Only those plants are preserved in museums that cannot be kept in herbaria, for example algae fungi, Mosses and ferns. Parts of gymnosperms, fruits, underground storage organs. Animals are preserved in chemical solutions (Formalin) as well as in stuffed and skeletal forms.

- Major Museums of the world
- American Museum of natural history, New York, USA
- State Museum of natural history, Stuttgart, Germany
- Museum of natural history, Switzerland.
- National museum of natural history, Paris
- National museum of natural history, Barakhamba Road, New Delhi
- Museum of Mumbai natural history society (Hornbill House, Shaheed bhagat singh road, Mumbai)

National Museum of Natural History, New Delhi

National Museum of Natural History, NY, USA

Zoological Parks

This is a place where wild animals are kept in their enclosures, these parks provide a natural environment. The scientific purpose of zoos is to breed the animals which otherwise are facing a threat in their natural habitat due to developmental activity they are facing poaching and habitat destruction.

Delhi Zoo

Berlin Zoo

Keys

A scheme for the identification of plants and animals are known as keys. The term key refers to a set of alternate characters in such a manner that it helps in the identification of an organism by selecting or eliminating the characters according to their presence or absence in the organism thus, taxonomic keys are based on the contrasting character.

- Separate taxonomic keys are required for each taxonomic category like family, genus or species. These are more useful in identification of unknown organisms.

- Being analytical in nature these are generally of two types, yoked or indented and bracketed.
- The indented key provides a sequence of choice between two or more statements of character of species. The user has to make the correct choice for identification. In a bracketed key the pairs of contrasting characters are used for identification and they are given numbers in brackets. The number on the right indicates the next choice of paired contrasting character.
- Identification of unknown specimens is usually made by using a key — that is, a device in which successive choices between contrasting statements are followed until the correct name is found by the process of elimination. Keys play an integral part in a flora, allowing for proper identification of families, species, and intraspecific taxa.

Monograph

In biological taxonomy a monograph is a comprehensive treatment of a taxon. Monographs typically revise all known species within a group, add any newly discovered species, and collect and synthesize available information on the ecological associations, geographic distributions, and morphological variations within the group. Example: Lent & Wygodzinsky, 1979, Revision of the Triatominae (Hemiptera, Reduviidae), and their significance as vectors of Chagas' disease.

Bulletin of the American Museum of Natural History v. 163, article 3, pp.125–520.

The first-ever monograph of a plant taxon was Robert Morison's 1672 *Plantarum Umbelliferarum Distribution Nova*, a treatment of the Apiaceae.

Summary

The basics of taxonomy like identification, naming and classification of organisms are universally evolved under international codes. Based on the resemblances and distinct differences, each organism is identified and assigned a correct scientific/biological name comprising two words as per the binomial system of nomenclature. An organism represents/occupies a place or position in the system of classification. There are many categories/ranks that are generally referred to as taxonomic categories or taxa. All the categories constitute a taxonomic hierarchy. Taxonomists have developed a variety of taxonomic aids to facilitate the identification, naming, and classification of organisms. These studies are carried out from the actual specimens which are collected from the field and preserved as referrals in the form of herbaria, museums, and in botanical gardens and zoological parks. It requires special techniques for the collection and preservation of specimens in herbaria and museums. Live specimens, on the other hand, of plants and animals, are found in botanical gardens or in zoological parks. Taxonomists also prepare and disseminate information through manuals and monographs for further taxonomic studies. Taxonomic keys are tools that help in identification based on characteristics.